# FLORA OF THE LOWER CRETACEOUS CEDAR MOUNTAIN FORMATION OF UTAH AND COLORADO, PART II. *MESEMBRIOXYLON STOKESI*

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Abstract.— *Mesembrioxylon stokesi*, sp. nov., from the Lower Cretaceous Cedar Mountain Formation of Utah is described and compared with other species of *Mesembrioxylon*. *Mesembrioxylon stokesi* is similar to Aptian members of this genus in having a combination of wood parenchyma and septate tracheids. This lends some support to the Cedar Mountain Formation being partially Aptian in age.

The Lower Cretaceous Cedar Mountain Formation is exposed throughout much of eastern Utah, western Colorado, and north central New Mexico (Young 1960). This formation is fossiliferous at several localities. Fisher et al. (1960) listed the formation as Aptian. It is still uncertain, however, whether it is Aptian, Albian, or both. Fossil plants reported from the Cedar Mountain Formation include *Tempskya* (Katich 1951, Stokes 1952, Tidwell and Hebbert 1972, Tidwell et al. 1976), cycadeoids (Furniss and Tidwell 1972), and dicotyledonous wood (Thayn et al. 1983). This paper is the first detailed report on coniferous woods from this formation.

The specimens of fossil woods consituting this report were collected from Molen Ridge, Emery County, Utah (Thayn et al. 1983). The Cedar Mountain Formation at this locality consists of a cap of coarse-grained, white sandstone that is underlain by channel fills of alternating yellow conglomeritic sandstone and grey-green shales. These beds are underlain by a dark green, nodular, weathering shale. The petrified logs at this site are highly

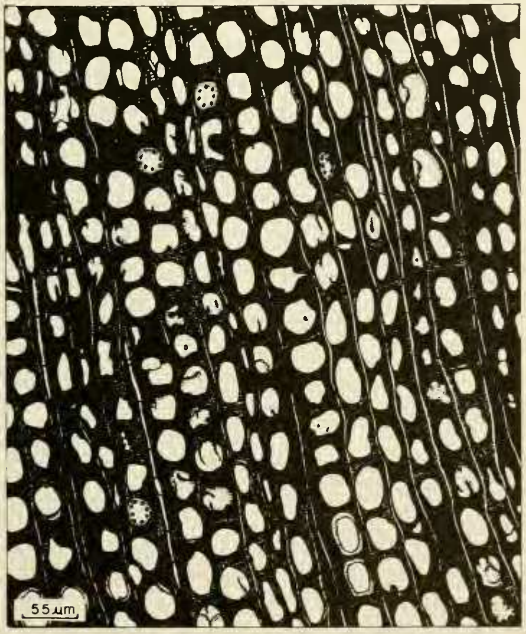


Fig. 1. Illustration of the transverse section showing distribution of axial parenchyma and general shape and arrangement of tracheids of *Mesembrioxylon stokesi* (Holotype).

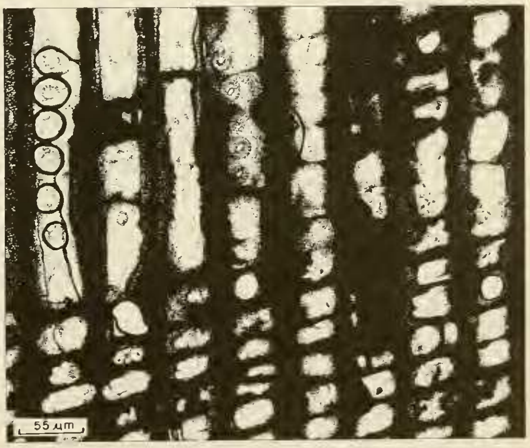


Fig. 2. Radial section showing the size and arrangement of radial tracheary pitting, presence of axial parenchyma, septations in the tracheids and the crossfields of *Mesembrioxylon stokesi* (Holotype).

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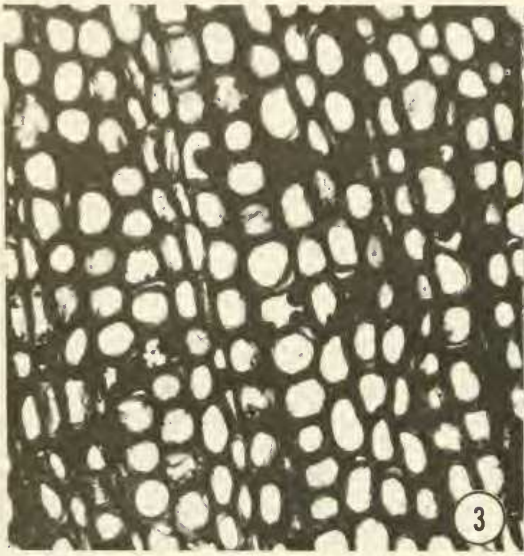


Fig. 3. Transverse section showing general shape and size of tracheids, diffuse axial parenchyma, and rays (250x) of *Mesembrioxylon stokesi* (Holotype).


Fig. 4. Tangential section illustrating the abundance and size of the rays and ray cells (150x) of *Mesembrioxylon stokesi* (Holotype).

fragmented and lie on the surface of the yellow channel fills. Other coniferous woods, dicotyledonous woods, and *Tempskya* have also been collected at this site.

*Mesembrioxylon stokesi*, sp. nov.

Description and diagnosis.— Growth rings indistinct with only a few layers of late wood cells; ring width varies 1.3–9.2 mm; transition from early to late wood gradual. Tracheids square, rectangular or oval in outline, with walls 7–10 μm; tracheid size ranges from 18 μm and isodiametric to 55 μm radial diameter by 18 μm tangential diameter; intercellular space common in late wood. Tracheids septate; radial tracheary pitting uniseriate, generally separate but occasionally vertically contiguous, circular bordered pits 10–19 μm in diameter. Pit apertures either circular or elliptic and small (3 μm) in relation to the size of the pit; crassulae lacking. Tangential pitting not apparent. Axial parenchyma abundant, 12–60 cells/mm$^2$. Parenchyma resinous, filled with dark cell contents. Axial parenchyma cells 40–210 μm high and up to 35 μm in diameter with 2–3 μm thick walls. Rays abundant, 9–14/tangential mm; 1–8 (ave. 4) rows of tracheids between the rays. Rays entirely parenchymatous; marginal cells wavy in outline. Rays uniseriate to partially biseriate, 1–50 (generally 8–16) cells (870 μm) high. Horizontal and tangential walls of ray cells smooth to slightly nodular and 2–3 μm thick (common wall). Ray cells square to rectangular; 35–125 μm radial diameter, 8–35 μm both tangential and vertical diameter. Crossfield pitting of two types; generally one podocarpoid pit per crossfield or very rarely 1–3 small bordered pits with slitlike apertures. Pits up to 18 μm in diameter, generally with broad border and with elliptic to square-oblong apertures, rarely thin borders with diagonally or vertically oriented elliptic apertures that range 3–9 μm at the widest point. Small crossfield pits approximately 4–8 μm in diameter with slitlike apertures.

Repository: Brigham Young University 2192 (Holotype).

Locality: Molen Ridge (Ferron Site) 9 miles east of Ferron, Utah (U.S. Geol. Surv.: Desert Lake Quadrangle NE, SW, Sec. 23, T20S, R8E).

Horizon: Lower Cretaceous Cedar Mountain Formation.

Affinities.— The most characteristic feature of *Mesembrioxylon stokesi* is the large

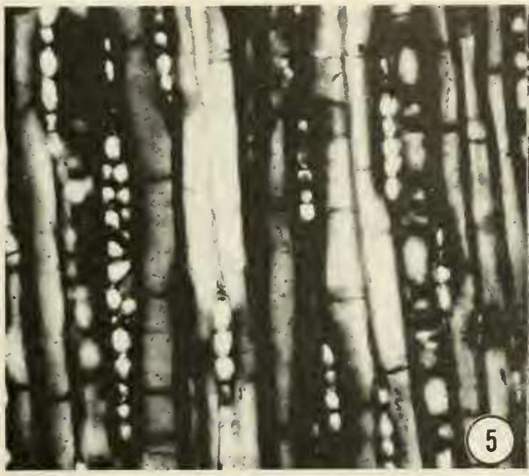

Fig. 5. Tangential section showing axial parenchyma, a partially biseriate ray and numerous septations in the tracheids (250x) of *Mesembrioxylon stokesi* (Holotype).

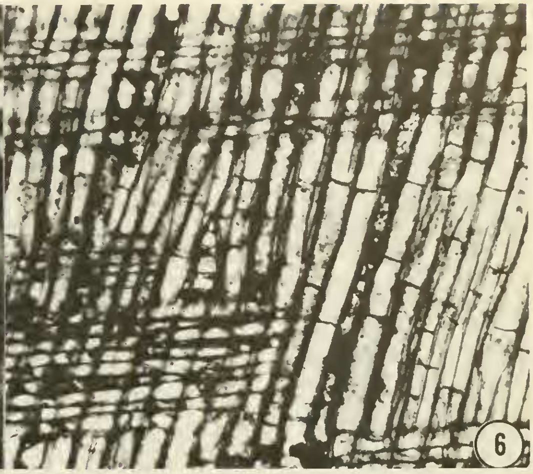

Fig. 6. Radial section demonstrating axial parenchyma; septate tracheids, crossfield pitting, and relative size of ray cells (153x) of *Mesembrioxylon stokesi* (Holotype).

open pits seen in the crossfields. Among extant woods this type of pitting occurs in several members of the Podocarpaceae and in the genera *Juniperus* (Cupressaceae), *Pinus* (Pinaceae), and *Sciadopitys* (Taxodiaceae). In 1905 Gothan proposed the name *Phyllocladoxylon* for petrified conifer wood that lacks resin canals and wood parenchyma but has one simple ray pit (phyllocladoid) per crossfield and separate circular bordered pits on the tracheids. The name *Podocarpoxylon* was also established by Gothan (1905) for fossil conifer wood with wood parenchyma and bordered crossfield pits with large elliptic apertures (podocarpoid pits). Stopes (1915) combined Gothan's genera into *Podocarpoxylon* pointing out that the two could not be distinguished on the basis of the crossfield pitting since both types of pits occur in the various species of both *Podocarpus* and *Phyllocladus*. Seward (1919) established the genus *Mesembrioxylon* because he thought, when there is no evidence of affinity with any particular living genus, a name free from implication should be used.

Krausel (1949) maintained a distinction between *Phyllocladoxylon* and *Podocarpoxylon* also on the basis of the crossfield pitting. He defined *Podocarpoxylon* as having small crossfield pits with vertical to steeply inclined apertures, whereas *Phyllocladoxylon* was to have large crossfield pits with oblique-elliptic apertures. Nevertheless, Bhardwaj (1953), Ramanujam (1953), Jain (1964), and Nishida (1966) all retained Seward's *Mesembrioxylon*.

About 30 species have been described as *Mesembrioxylon*, *Phyllocladoxylon*, or *Podocarpoxylon*. All but four of these species differ from *M. stokesi* by having different combinations of ray height, size and number of crossfield pits, axial parenchyma, configuration of tracheary pitting, and lack of septations in the tracheids (Table 1).

*Mesembrioxylon woburnense* (Stopes) Seward (1919) resembles *M. stokesi* in having rays varying from 1 to over 40 cells high and are occasionally partially biseriate. It differs in lacking septations in the tracheids and by having 1 or 2 pits in the crossfield that are in one horizontal row. It also has crassulae that are lacking in *M. stokesi* and radial tracheary pitting that is occasionally in two opposite rows rather than exclusively uniseriate.

Of the described species of *Mesembrioxylon* only *M. nihei-takagi* Nichida (1966) and *M. gothani* (Stopes) Seward (1919) have a combination of septate tracheids and wood parenchyma similar to *M. stokesi*. *Mesombrioxylon nihei-takagi* has rays up to 10 cells high that are uniseriate or partially biseriate and parenchyma in tangential bands. *M. stokesi* has rays up to 50 cells high that are uniseriate or partially biseriate and diffuse wood parenchyma. *Mesembrioxylon gothani*, as originally described by Stopes (1915), has rays of 1–8 cells high that are exclusively uniseriate and scattered wood parenchyma. Shimakura (1937) reported a specimen of this species that had rays up to 18 cells high. *Mesembrioxylon stokesi*, however, has higher rays that are partially biseriate. *Mesembrioxylon stokesi* has a ray structure similar to *M. woburnense* and septate tracheids and crossfield pitting like *M. gothani*. Thus, *M. stokesi* appears to be a new species intermediate between the two.

*Xenoxylon morrisonense* Medlyn and Tidwell (1975) from the Upper Jurassic Morrison Formation, which underlies the Cedar Mountain Formation, is anatomically very close to *Mesembrioxylon stokesi*. They are similar in that both have septate tracheids and large podocarpoid crossfield pits. These species differ in that *M. stokesi* has broad borders on its podocarpoid pits as compared with the narrow borders in *X. morrisonense*. *M. stokesi* has smooth horizontal and end walls in its ray parenchyma and numerous resin cells, and its few contiguous bordered pits are not flattened as in *X. morrisonense*, a feature characteristic of most *Xenoxylon* species. Horizontal and end walls of ray parenchyma in *X. morrisonense* have numerous indentations and it lacks resin in any of its cells.

*Protocedroxylon scoticum* (Holden) Seward (1919) is also similar to *Mesembrioxylon stokesi*. However, *P. scoticum* has araucarian pitting (Holden 1915), which is lacking in *M. stokesi*.

The specific epithet of *Mesembrioxylon stokesi* is given in honor of Dr. William Lee Stokes of the University of Utah, who first collected specimens of fossil wood from the Molen Ridge site.

STRATIGRAPHIC RELATIONSHIPS.— It is not presently known whether the Cedar Mountain Formation is Aptian or Albian in age. The presence of dicotyledonous woods in the formation (Thayn et al, 1983) possibly makes

TABLE 1. Comparison of *Mesembrioxylon stokesi* with similar species.

| Species | Ray height | Tracheid septations | Radial pit size | Crossfield pitting | Axial parenchyma | crassulae | Size and shape of Tracheids (x-sec) |
|---|---|---|---|---|---|---|---|
| *M. stokesi* | 1–18 to over 50 | thick walled | circular 10–19 µm | one large podocarpoid pit with broad borders, having 1–3 small border pits with lenticular apertures | abundant and diffuse | lacking | square or radially elongate 18 x 18 to 18 x 55 µm |
| *M. gothani* | 1–8, mostly 3 cells high (1–18 in Shimakura, 1937) | thin and horizontal | circular or ovoid, 15–17 µm celliptical pits | one or two 7 µm ovoid, circular or | sparse and diffuse | lacking | various, 20–25 µm |
| *M. nihei-takagi* | 1–4, rarely 8 cells high thin and horizontal | thin and ovoid, 8–10 µm | circular or three, 5–8 µm | one to and diffuse | abundant | lacking | tangentially elongate 15–22 µm |
| *M. woburnense* | 4–10, up to 35 cells high (over 40 in Shimakura, 1937) | lacking | circular, 9–15 µm | one to two in a horizontal row zontal row 10–15 µm | 10–15 µm zonate | sparse and | present rectangular to radially elongate, 30–39 µm |

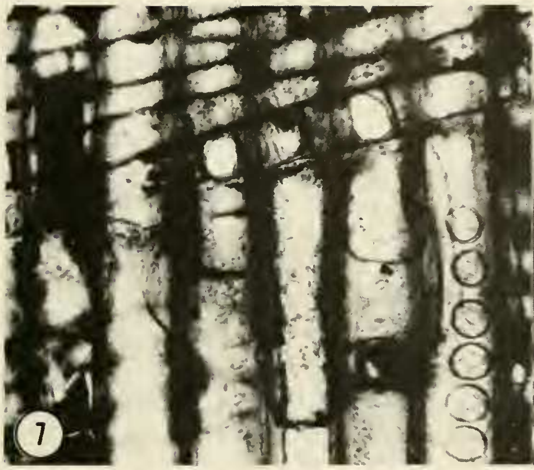

Fig. 7. Radial section showing two types of crossfield pits and circular radial tracheary pits (500x) of *Mesembrioxylon stokesi* (Holotype).

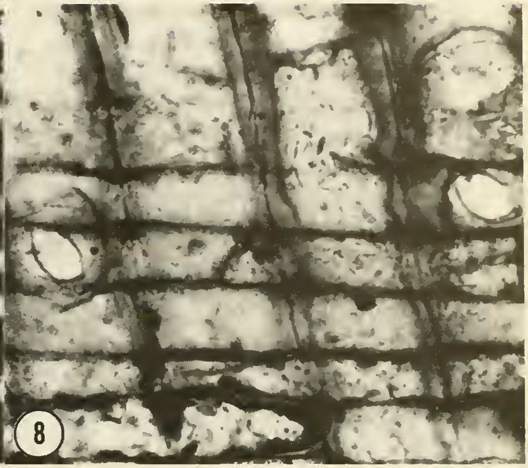

Fig. 8. Closeup of radial section of ray. Note the broad borders on the crossfield pits (1000x) of *Mesembrioxylon stokesi* (Holotype).

it Albian since reported Aptian dicotyledonous woods have been placed in doubt by Wolfe et al. (1975). *Mesembrioxylon* ranges from the Permian to the Pliocene, but the woods most comparable to *M. stokesi* were first collected from sediments reported as Aptian. *Mesembrioxylon gothani* and *M. woburnense* have been collected from the Aptian of England (Stopes 1915) and Japan (Nishida 1966). However, Shimakura (1937) reported both species from the Upper Cretaceous of Japan and *M. woburnense* was reported from the Tertiary of India (Ramanujam 1953). The only other species of *Mesembrioxylon* with septate tracheids and partially biseriate rays is *M. nihei-takagii* which was collected from the Aptian of Japan (Nishida 1966).

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## Literature Cited

BHARDWAJ, D. C. 1953. Jurassic woods from the Rajmahal Hills, Bihar. The Palaeobot. 2:59–70.

FISHER, D. J., C. E. ERDMAN, AND J. B. REESIDE. 1960. Cretaceous and Tertiary formations of the Book Cliffs, Carbon, Emery, and Grand Counties, Utah, and Garfield and Mesa counties, Colorado. U.S. Geol. Surv. Prof. Paper 332. 1–80.

FURNISS, B., AND W. D. TIDWELL. 1972. Cycadeoidales from the Cedar Mountain Formation near Moab, Utah. Geol. Soc. Amer. (Abstr.) 4(6):377.

GOTHAN, W. 1905. Zur anatomic lebender und fossiler Gymnopsermem-Holzer. Abh. K. Preuss. Geol. landes. 44:1–108.

HOLDEN, R. 1915. A Jurassic wood from Scotland. New Phyt. 14:205–209.

JAIN, K. P. 1964. A new species of *Mesembrioxylon*, *M. rasmahalense* from the Rajmahal Hills, Bihar, India. The Palaeobot. 13(2):153–154.

KATICH, P. J. 1951. Occurrence of *Tempskya* in the Lower Cretaceous of the Western Interior. J. Paleon., 26(4):677.

KRAUSEL, R. 1949. Die fossilen Koniferenholzer (unter Asschluss von *Araucarioxylon* Kraus) II. Tiel. Kritische untersuchungen zur diagnostik lebender und fossiler Koniferenholzer. Palaeontographica 89B:83–203.

MEDLYN, D. A., AND W. D. TIDWELL. 1975. Conifer wood from the Upper Jurassic of Utah, Part I: *Xenoxylon morrisonense*. Amer. J. Bot. 62(2):303–309.

NISHIDA, M. 1966. On some petrified plants from the Cretaceous of Choshi, Chiba Prefecture III. Bot. Mag. Tokyo 79:226–235.

RAMANUJAM, C. J. K. 1953. On two species of *Mesembrioxylon* from the vicinity of Pondicherry, South India. The Palaeobot. 2:101–106.

SEWARD, A. C. 1919. Fossil Plants. Vol. IV. Cambridge Univ. Press, London 543 pp.

SHIMAKURA, M. 1937. Studies on fossil woods from Japan adjacent lands II. The Cretaceous woods from Japan, Saghalien and Manchoukuo. Sci. Rep. Tohok. Imp. Univ. Sendai, Ser. 2, 19(1):1–73.

STOKES, W. L. 1952. Lower Cretaceous in Colorado Plateau. Amer. Assoc. Pet. Geol. Bull. 36(9):1774–1796.

STOPES, M. C. 1915. Catalogue of Mesozoic plants in the British Museum (Nat. Hist.). London. Pt. II:1–360.

THAYN, G. F., W. D. TIDWELL, AND W. L. STOKES. 1983. Flora of the Lower Cretaceous Cedar Mountain Formation of Utah and Colorado. Part I. *Paraphyllanthoxylon utahense*. Great Basin Nat. 43(3):294–402.

TIDWELL, W. D., AND N. HEBBERT. 1972. *Tempskya* from the Cedar Mountain Formation near Moab. Geol. Soc. Amer. (Abstr.) 4(6):417–418.

TIDWELL, W. D., G. F. THAYN, AND J. L. ROTH. 1976. Cretaceous and Early Tertiary floras of the Intermountain Area. Brigham Young Univ. Geol. Studies 22:77–98.

WOLFE, J. A., DOYLE, J. A., AND V. M. PAGE. 1975. The bases of angiosperm phylogeny: Paleobotany. Ann. Mo. Bot. Gard. 62:801–824.

YOUNG, R. G. 1960. Dakota Group of Colorado Plateau. Amer. Assoc. Pet. Geol. Bull. 44(1):156–194.